THE WEATHER AND CIRCULATION OF MARCH 1966

Generally Mild and Dry

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1. MONTHLY MEAN 700-MB. CIRCULATION

In March 1966 700-mb. flow (figs. 1 and 2) differed appreciably from the circulation in February 1966 [1]. Blocking remained active but its intensity and location were quite dissimilar this month.

Changes in anomalous heights from February to March are shown in figure 3. In the Atlantic, where a record negative height anomaly was observed at 50° N. in February, there was a maximum change of 1,000 ft. The large height increases over the Atlantic and substantial decreases over Greenland produced a strengthened westerly flow between 50° and 70° N. At the same time zonal flow decreased in the subtropical belt (20°–35° N.) in the Atlantic. This decrease was also generally true for the overall subtropical belt in the western portion of the Northern Hemisphere where the average westerly flow decreased to about normal in March after being about 2 meters per second higher than normal in February. The latter index had fallen from a maximum of about 3 m.p.s. in the mid-January to mid-February period. The slow decrease of the subtropical westerlies denotes a gradual receding of a previously expanded circumpolar vortex [2].

Figures 2 and 3 show that blocking was still prevalent over eastern North America in March but not in great strength. There may have been some slight westward spread of blocking as indicated by the height increases from February to March over central Canada and very small decreases over the eastern one-third of the United States.

In contrast to the increased zonal flow in middle latitudes of the Atlantic the flow in the Pacific became much less zonal. 700-mb. heights increased more than 600 ft. in the Bering Sea and decreased about 200 ft. to 400 ft. from the Gulf of Alaska to the central Pacific. It seems unlikely that the amplification was related to the decrease in Atlantic blocking.

Amplification in the Pacific was accompanied by a cyclonic center of action in the Gulf of Alaska where none had been so well-defined since December 1965. Strong northerly flow from the Arctic suggests the frequent transport of cold air over the relatively warm water of the eastern Pacific where combined baroclinic and barotropic effects produced frequent and deep storms at the surface. Sea level pressure averaged as much as 11 mb. below normal in the Gulf of Alaska for the month (fig. 4).

Deepening in the eastern Pacific contributed to ridging over western North America and troughing downstream. The trough in eastern North America was quite weak, however, except near Greenland where deepening took place as the warm blocking ridge was eroded.

Over Europe and western Asia the ridge in March retrograded from western Europe to the eastern Atlantic while blocking weakened and became reoriented. Average sea level pressure departure from normal reflected the upper-level reversal. In February sea level pressure was as much as 25 mb. below normal in the eastern Atlantic and in March more than 10 mb. above normal. The trough formerly over Russia retrograded and deepened over eastern Europe. This resulted in cooler than normal weather over North Africa and the Mediterranean coast of Europe.

Fast westerly flow prevailed over Asia with some southward displacement from normal of the mean jet axis in eastern Asia. Blocking remained in high latitudes but it was considerably weaker than in February. The trough along the Asian coast was somewhat farther west than in February as the flow became more meridional.

2. MONTHLY MEAN WEATHER

TEMPERATURE

March 1966 was unseasonably warm over most of the Nation (fig. 5) as blocking dominated the circulation over North America with 700-mb. heights above normal from Labrador to Alberta. This orientation of blocking favored considerable anticyclonic activity in Canada with occasional penetrations of cold air into the eastern one-third of the United States. Most of the Highs that moved through the Eastern States followed a track from Manitoba, very similar to a normal primary track [3], with an occasional maritime High from the West. Highs from both sources contributed to the average coolness in the Southeast. Temperatures here ranged to 3° F. below normal and 700-mb. heights were only slightly less than normal.

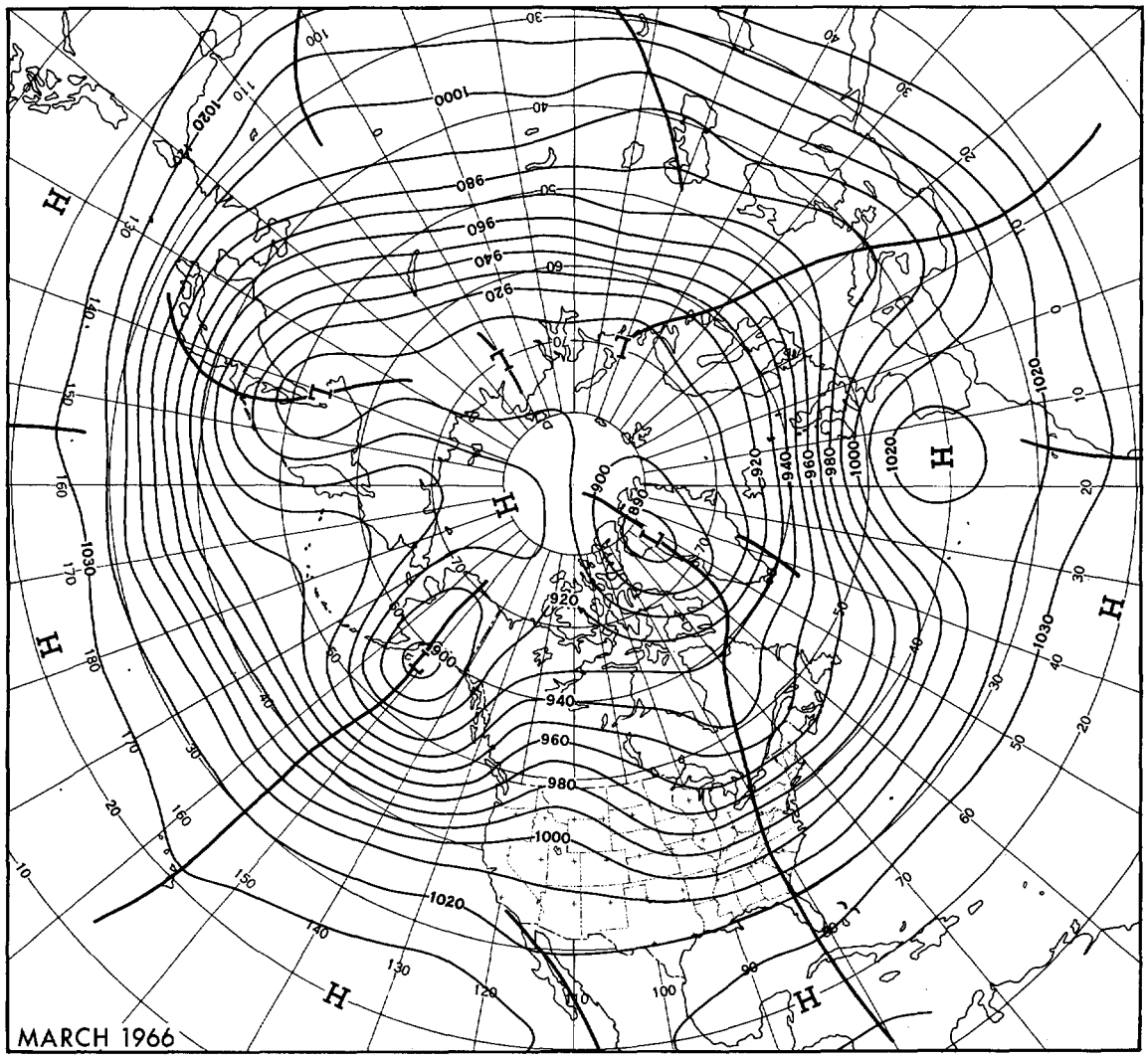

FIGURE 1.—Mean 700-mb. contours (tens of feet) for March 1966. Flow in the western portion of the Northern Hemisphere was somewhat slower than normal because of the deep Low in the Gulf of Alaska and blocking over eastern North America and the Atlantic Ocean.

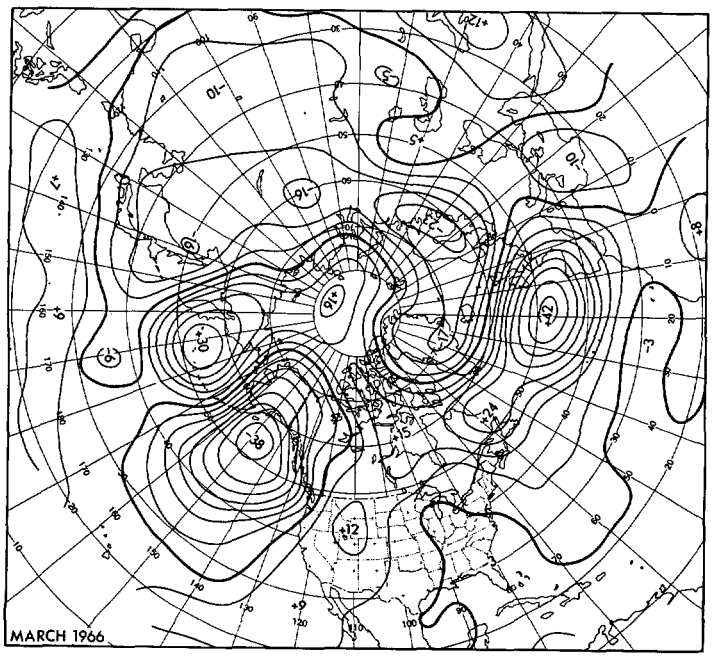

FIGURE 2.—Departure of mean 700-mb. heights from normal (tens of feet) for March 1966. Absence of a strong anomalous flow from a cold source and above normal heights were responsible for mild weather.

Temperature changes indicate very little persistence from February to March compared with the cold weather of January and February over most of the Nation. The warming trend this month affected 80 out of 100 representative stations where average temperatures increased by 1 to 3 classes (out of 5*); only three stations were cooler in March than in February. Most of the increases of 2 or 3 classes were in the Southwest and Northern Plains States. In the latter area temperatures averaged 6°–7° F. above normal for the month.

PRECIPITATION

Quite dry conditions prevailed over the southern two-thirds of the United States in March 1966 (fig. 6). Heaviest precipitation relative to normal fell in portions of the Pacific Northwest, the Northern Plains, and New Eng-

*The upper and lower octiles, and the middle three quartiles.

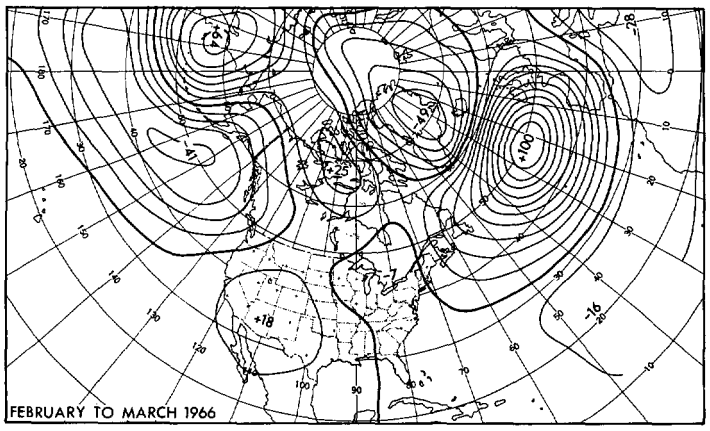

FIGURE 3.—Mean 700-mb. height anomaly change (tens of feet) from February to March 1966. Changes were rather small over the United States but were substantial in the Pacific where the flow became more meridional; in the Atlantic blocking formerly in high latitudes moved to middle latitudes.

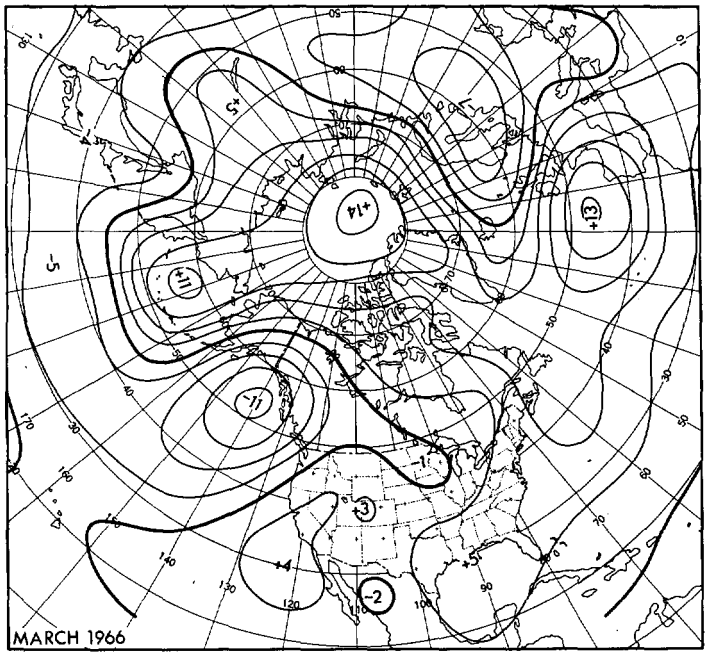

FIGURE 4.—Departure of mean sea level pressures from normal (mb.) for March 1966. Sea level pressure was unusually high in the Arctic and the Atlantic; in the Pacific the band of negative pressure anomaly in middle latitudes suggests that the track of cyclones (chart IX of [5]) was somewhat farther south than normal.

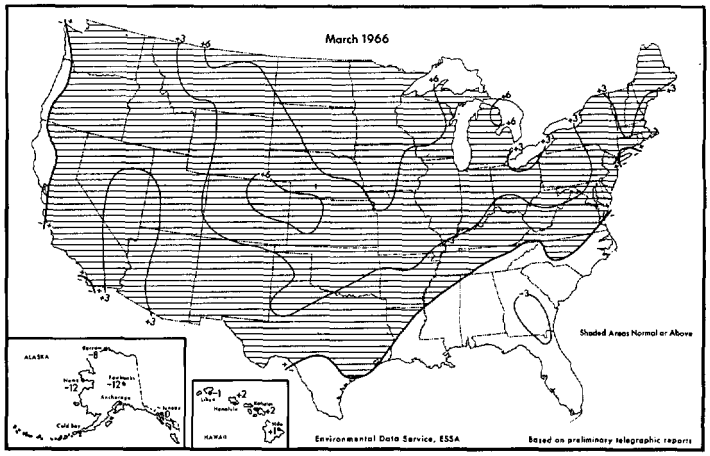

FIGURE 5.—Departure of average surface temperature from normal (°F.) for March 1966 (from [4]). Mild weather dominated the Nation except in the Southeast where temperatures averaged a few degrees lower than normal.

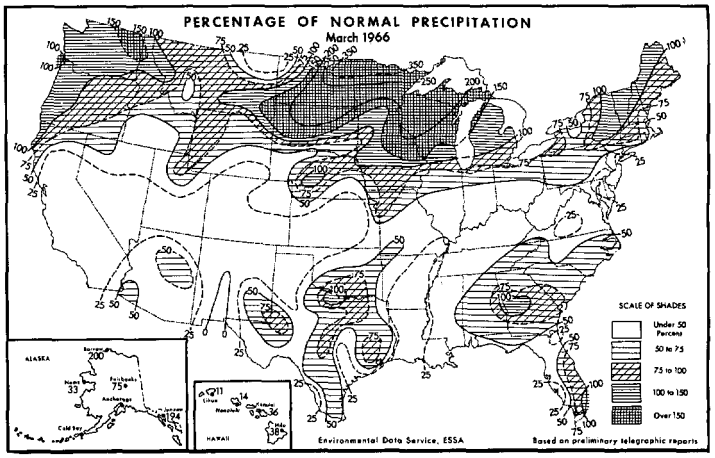

FIGURE 6.—Percentage of normal precipitation (in.) for March 1966 (from [4]). The lower two-thirds of the United States and drought areas in the East received much less than normal precipitation.

land. Rainfall in Washington and Oregon was near to above normal for this time of year and related to the strong southerly anomalous component of the mean flow associated with the deep mean trough in the eastern Pacific.

In the Northern Plains much of the precipitation came with the severe blizzard during the first week. Although the water equivalent of the widespread heavy snow was only 1–2 in. this was sufficient to account for two to three times the normal precipitation. Anomalous flow was northeasterly and northerly in this area, not suggestive of heavy precipitation. In the Great Lakes the anomalous flow appeared more favorable for heavy precipitation.

Northern New England had normal to above precipitation this month, with some heavy snow. In most of the area where long-term drought has been a problem, precipitation was much less than normal. Table 1 shows cities in the East where subnormal precipitation this month contributed to drought.

The location of the trough in eastern United States seemed to be ideal for heavy precipitation from New England to the Middle Atlantic States. However, its presence was not a sufficient condition for creating heavy precipitation. Missing this month was a sustained flow or anoma-

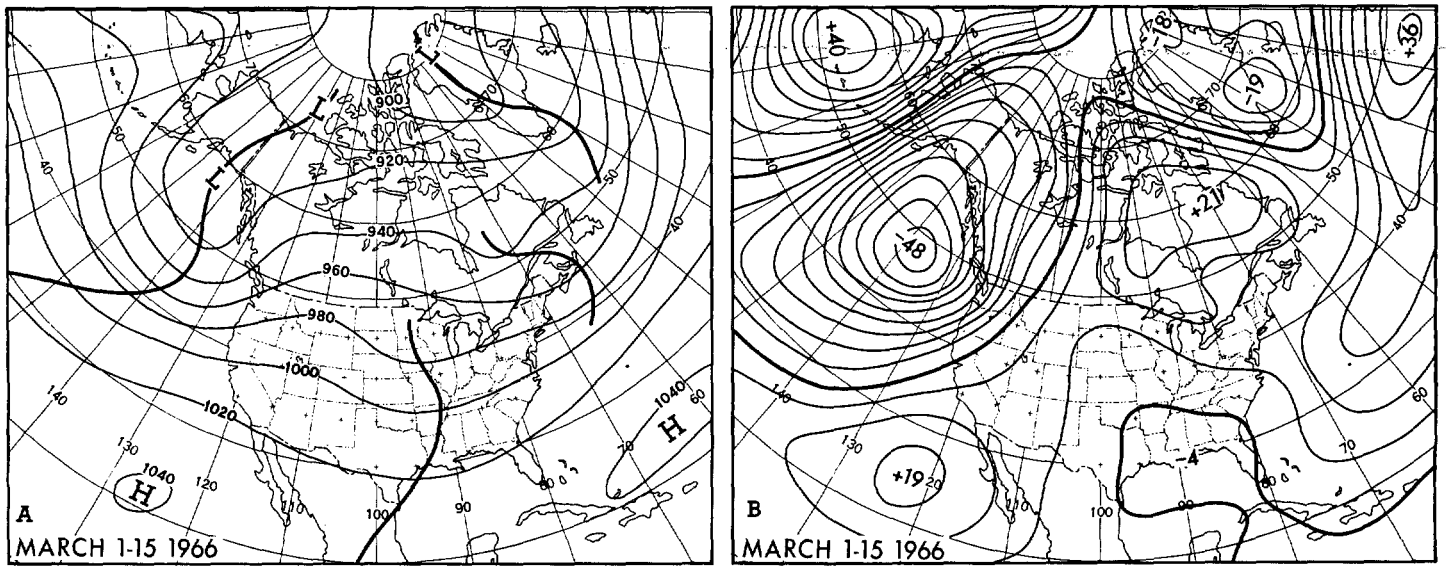

FIGURE 7.—Mean 700-mb. contours (A) and height departure from normal (B) (both in tens of feet) for March 1–15, 1966.

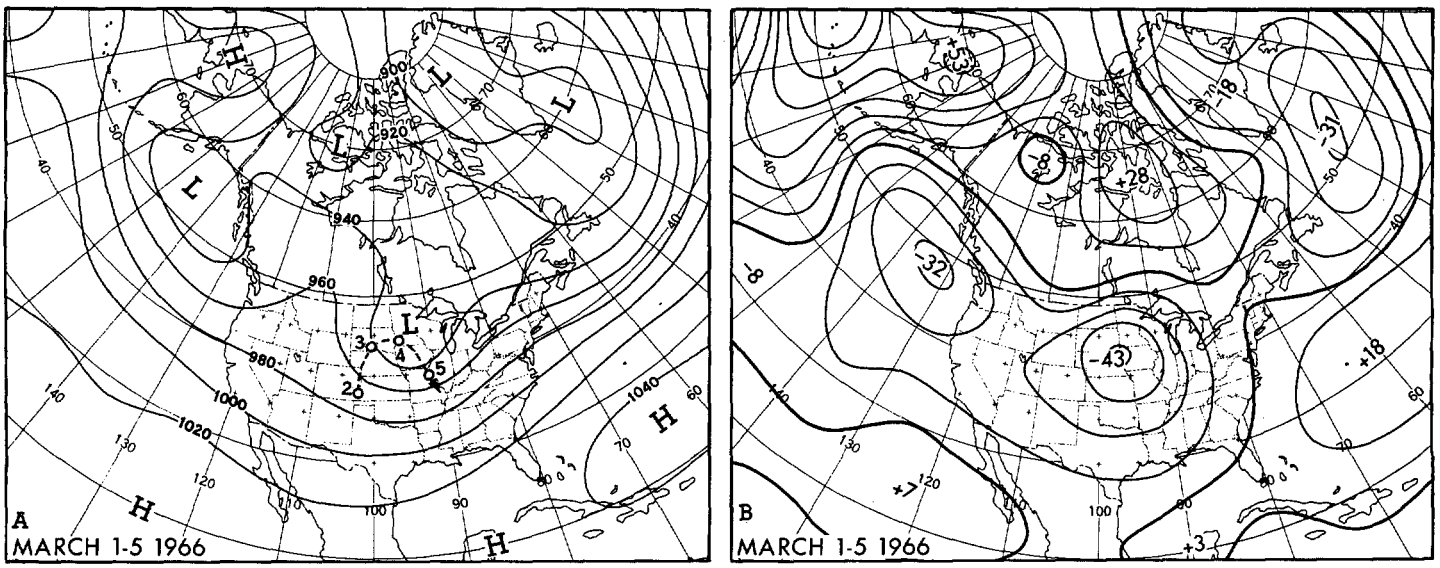

FIGURE 8.—Mean 700-mb. contours (A) and height departure from normal (B) (both in tens of feet) for March 1–5, 1966. Circles with dates show positions of surface Low. Slow motion of the surface storm was related to above normal heights over Canada.

TABLE 1.—*Total precipitation and deficits for March 1966 in representative cities in the drought area*

City	Precipitation (in.)	
	Observed	Deficit
Boston, Mass.	2.08	2.14
New York (La Guardia), N.Y.	1.37	2.86
Atlantic City, N.J.	1.19	2.72
Philadelphia, Pa.	1.01	2.79
Wilmington, Del.	0.81	3.21
Washington, D.C.	1.50	1.71
Richmond, Va.	0.93	2.49
Norfolk, Va.	1.60	1.85
Roanoke, Va.	0.44	3.11
Charleston, W. Va.	1.58	2.76
Pittsburgh, Pa.	2.08	1.24

lous flow from the Gulf of Mexico or from the Atlantic off the southeastern coast. Surface disturbances were deflected farther south than usual and deepening occurred so far offshore that coastal States received little benefit from the rainfall produced.

3. HALF MONTHLY FEATURES

MARCH 1–15

Charts of the mid-tropospheric flow during the first half of March (fig. 7) show a deep Low in the Gulf of Alaska.

This Low and its trough to the southwest represented some progression and considerable deepening over the trough in the eastern Pacific the last half of February.

Over the United States the trough in the Mississippi Valley was quite weak, but it was accompanied by a severe surface storm. The rather short wave-spacing between this trough and the one in the eastern Pacific was probably related to blocking that moved into eastern Canada the first half of March. This blocking ridge was not particularly strong but the warming associated with it was extensive. Temperatures in Michigan, Wisconsin, and Minnesota were 5°–15° F. above normal and weather was relatively warm elsewhere in the eastern two-thirds of the Nation except in the Gulf Coast States. Here temperatures were as much as 4° F. below normal and freezing temperatures were recorded in central portions of northern Florida. Temperatures in the West were normal to slightly below normal except for several stations from Nevada to western Montana that had warm weather.

During the first week of March a severe blizzard paralyzed most of the Northern Plains. As this storm drifted slowly eastward out of the northern Rockies as much as 3 ft. of snow fell in some localities with gusting winds over 70 m.p.h. that caused drifts to 20 ft. Record March snowfall was reported at Billings, Mont. (11 in.) and at Bismarck, N. Dak. (22 in.). Early reports indicate at least 15 dead and very heavy livestock losses in this storm, said to be the worst in the last 50–60 years.

Deepening proceeded from the 500-mb. level to the surface on March 3 as the storm fed on the developmental thermal gradient created as very cold air moved into the West. Ordinarily the storm might have moved across the Lakes and into a center of action elsewhere, but in effect it became a mean feature associated with blocking.

The slow motion of this storm was somewhat unusual but when viewed in retrospect in the format of the 5-day mean circulation its behavior seems less mysterious. The 5-day mean contour chart for March 1–5 (fig. 8A) indicates what appears to be a rather simple flow with a deep Low over Minnesota (with 24-hr. positions of the storm) and a trough to Texas. To the west there was a ridge over western North America and a deep Low in the Gulf of Alaska. The important aspects of this circulation are clarified in figure 8B, the 5-day mean height anomaly chart for March 1–5. The stalling now seems more reasonable as blocking is accented by the above normal heights in Canada and below normal heights over the United States. This indicates a marked decrease in the westerlies and, of course, a decrease in the usual eastward motion of surface features along 40°–50° N. Westerlies were displaced far to the south as below normal heights reached south of 30° N. The weekly temperature chart for this period (fig. 9) shows the sweep of cold air from the Canadian border to the Mexican border and then eastward in the strong westerly flow through the Gulf Coast States. There were record low temperatures for March in Utah

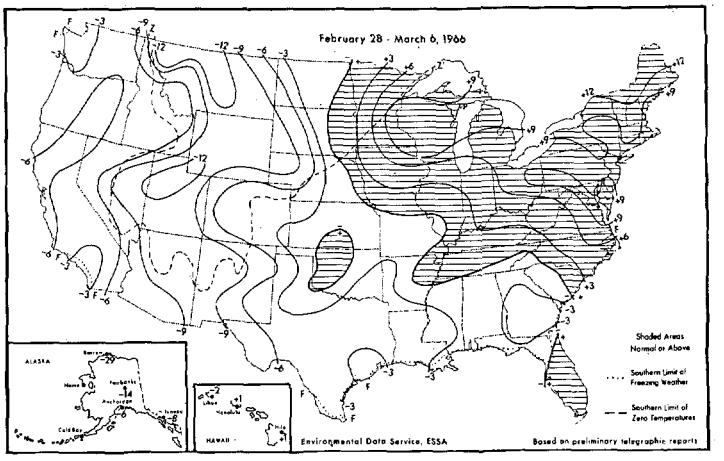

FIGURE 9.—Departure of average surface temperature from normal (°F.) for February 28–March 6, 1966 (from [4]). Very cold air in the West and Gulf Coast States followed the severe blizzard this week.

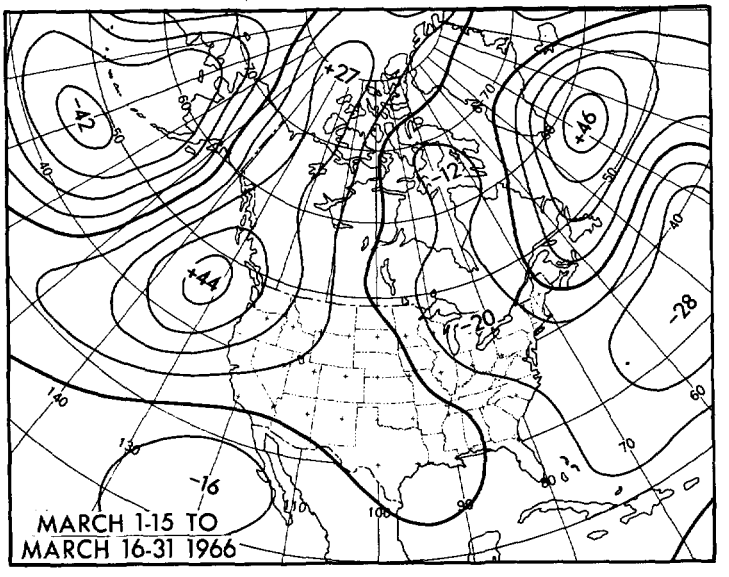

FIGURE 10.—Mean 700-mb. height anomaly change (tens of feet) for March 1–15 to March 16–31, 1966. Height anomaly decreases over eastern Canada reflect weakening of the blocking.

(Milford, −14° F. and Salt Lake City, 2° F.) and Arizona (Flagstaff, −16° F.). Heavy rains and severe weather accompanied the leading edge of the cold air as it moved into the Southeast. Tornadoes in Mississippi and Alabama took more than 60 lives and caused property damage estimated above $12 million.

MARCH 16–31

Changes from the first half of March to the last half (fig. 10) were related to some decrease in blocking. Heights at 700 mb. increased by some 400 ft. off the Pacific Northwest coast and by about 200 ft. in western Canada. This may have been a response to some retro-

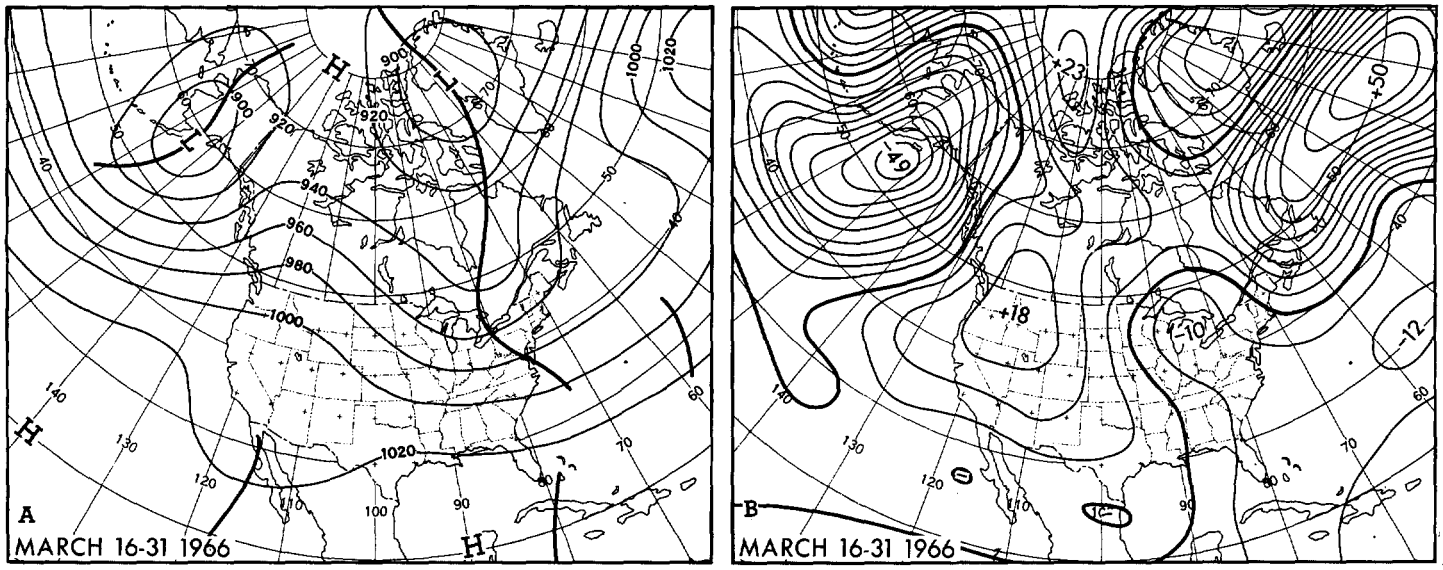

FIGURE 11.—Mean 700-mb. contours (A) and height departure from normal (B) (both in tens of feet) for March 16–31, 1966.

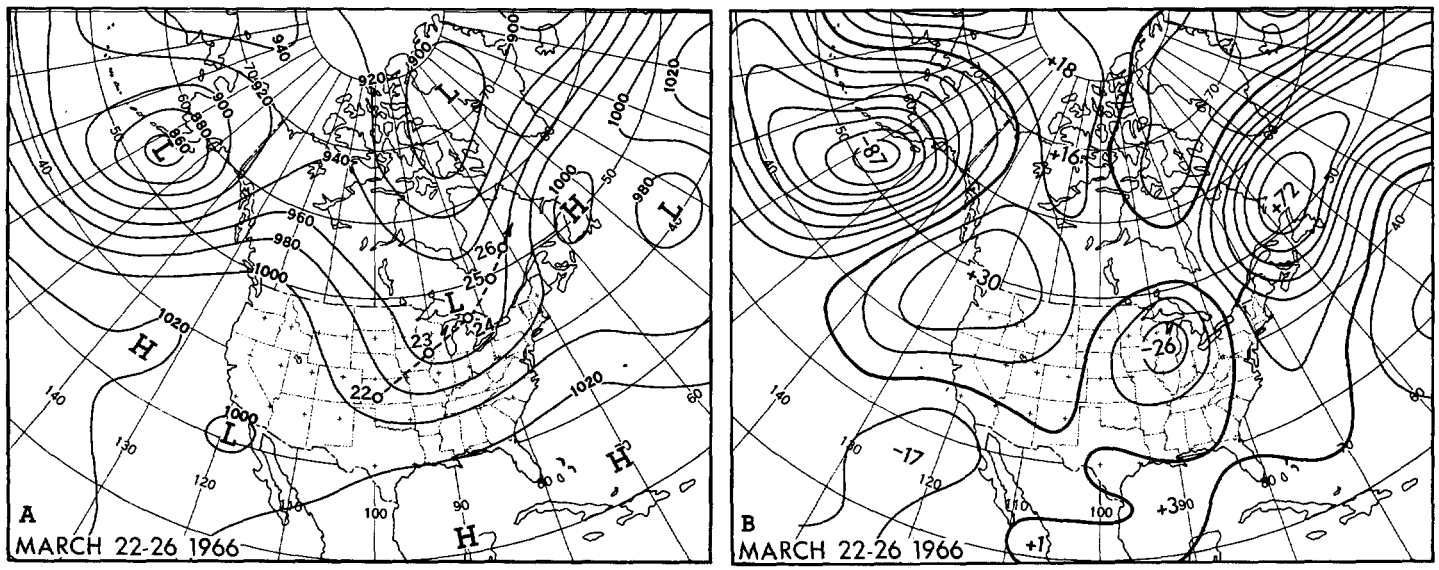

FIGURE 12.—Mean 700-mb. contours (A) and height departure from normal (B) (both in tens of feet) for March 22–26, 1966. Circles with dates show positions of surface Low. Speed of the surface Low was retarded slightly as it approached the blocking now in eastern Canada.

gression of blocking or to deepening of the eastern Pacific trough some 10° longitude farther west, or to both. Meanwhile the wave spacing expanded (fig. 11) as a trough deepened over the eastern one-third of the United States. 700-mb. heights decreased here by about 200 ft. from the first half of the month and the contour curvature became strongly cyclonic.

Temperatures responded to the height changes in a familiar manner. As the trough deepened, marked cooling occurred over most of the eastern two-thirds of the country. Temperature anomalies decreased 4°–7° F. from Minnesota to the Ohio Valley, but this was not enough to cause temperatures to average below normal for the two-week period. Associated with the ridging over the West was warming of 2°–6° F. in the Northern Plains States. In the Southern Plains and Gulf Coast States anomalous temperatures increased 2°–5° F. and Florida remained cooler than normal.

Another major blizzard occurred this month about three weeks after the first one. This too was a serious storm in that many deaths resulted. However, much less capital loss and inconvenience were apparent. This storm moved quite fast compared with the first one and

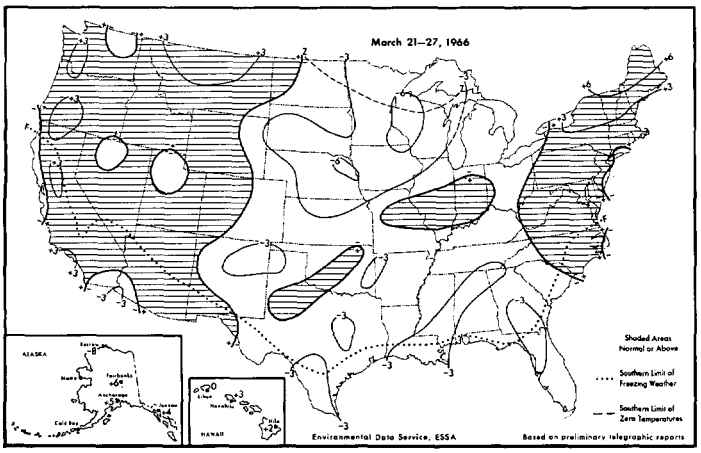

FIGURE 13.—Departure of average surface temperature from normal (°F.) for March 21–27, 1966 (from [4]). Cold air that followed the second blizzard was neither as extensive nor as cold as the influx that followed the first blizzard.

produced much less snow. Up to a foot fell from the Central Plains to Minnesota, 20 in. in Upper Michigan, and more than a foot in the lee of Lake Erie. In New England precipitation was mostly rain with some snow in the north. Elsewhere in the East precipitation was generally less than half an inch in thundershowers along the cold front.

Upper-level flow for the 5-day mean period that included this storm is shown in figure 12. The deep Low over the Lakes and a trough to the Southern Plains were somewhat similar to the first storm but a little farther east. Blocking was an important factor again in the 5-day mean circulation but its interaction with the storm was entirely different. In this instance the blocking was over eastern Canada and there was little easterly anomalous flow over central Canada. Thus the storm did not stall as the first one did (see tracks, figs. 8A and 12A) but was steered northward after leaving the Great Lakes by the strong southerly flow.

Figure 13 shows the surface temperature anomaly for the week during which the second blizzard occurred. The air mass that followed the cold front was considerably warmer than the earlier cold outbreak. During the first week (fig. 9) the zero isotherm reached as far as northern Arizona; with the second surge of polar air zero temperatures barely reached into Wisconsin. Coldest weather for the week occurred over a very small area in the Upper Mississippi Valley where actual temperatures were only 6° F. below normal.

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